

Table 6. Measurements (in mm) taken on the major chelae of male *Callianopsis clallamensis* (Withers).

USNM Number	L1	L2	L3	L4	H1	H2
490203	27.9	>12.4	>6.9	20.6	18.8	20.0
490210	>32.3	>18.4	>7.6	25.0	18.8	22.7
490211	>27.1	>14.0	>4.8	17.8	—	17.2
490202	23.2	—	—	16.2	14.7	16.2
490201	34.6	—	12.0	21.8	17.1	19.4
490197	27.7	—	8.7	17.0	15.6	17.3
490209	25.1	13.3	8.1	—	—	14.5
490198	—	—	—	18.8	17.4	19.0
490208	29.6	—	9.7	17.7	—	17.2
490206	29.4	—	—	17.7	15.4	18.0
490199	—	16.3	9.4	—	—	—
490205	>30.3	9.3	15.8	19.4	16.0	18.4
490212	>24.6	—	—	—	—	—
490204	27.3	—	—	16.6	—	16.3
490227	13.0	—	3.7	8.7	7.2	8.3
490226	>31.3	—	10.3	>17.2	—	15.8
490207	33.5	—	—	21.9	17.1	19.2

Table 7. Measurements (in mm) taken on the minor chelae of female *Callianopsis clallamensis* (Withers).

USNM Number	L1	L2	L3	L4	H2
490217	>12.0	5.7	5.6	9.3	5.0
490214	>9.7	5.5	5.6	8.5	>4.4

Table 8. Measurements (in mm) taken on the minor chelae of male *Callianopsis clallamensis* (Withers).

USNM Number	L1	L2	L3	L4	H2
490198	16.5	7.0	7.5	11.9	4.9
490207	18.4	—	8.4	11.1	5.7

Table 9. Measurements (in mm) taken on the merus and carpus of the major cheliped of female *Callianopsis clallamensis* (Withers). H = maximum height; L = maximum length.

USNM Number	L-carpus	H-carpus	L-merus	H-merus
490213	>11.6	>7.5	—	—
490218	11.0	6.4	—	—
490228	11.0	6.6	9.4	5.1
490214	12.6	6.2	—	—
490217	—	—	9.4	5.9

Table 10. Measurements (in mm) taken on the merus and carpus of the major cheliped of male *Callianopsis clallamensis* (Withers). H = maximum height; L = maximum length.

USNM Number	H-carpus	L-carpus	H-merus	L-merus
490200	12.8	8.5	—	10.5
490211	10.5	17.8	—	—
490202	14.3	7.3	—	10.2
490198	17.7	10.6	—	—
490197	14.9	>7.5	7.5	12.4
490199	—	—	8.5	13.4
490207	18.1	10.3	6.9	12.1

Table 11. Measurements taken on the meri of pereopods of *Callianopsis clallamensis* (Withers). L = maximum length; W = maximum width.

USNM 490206	L	W
Third pereopod	13.5	4.8
Second pereopod	>11.9	3.9

Makah Formation. The Makah Formation is believed to have been deposited in a deep marginal basin (Snaveley *et al.*, 1980), at depths from 300–1,830 m (Rau, 1964). The Jansen Creek Member lies near the middle of the Makah Formation and is believed to be late Eocene in age based upon mollusc and foraminifera assemblages (Snaveley *et al.*, 1980). It is overlain by beds that are Oligocene in age (Snaveley *et al.*, 1978). The Jansen Creek Member is believed to be an allochthonous unit resulting from erosion of uplifted, older rocks that bordered the deep marginal basin where the Makah Formation was being deposited (Snaveley *et al.*, 1980). Most of the decapods of the Makah Formation have been collected from the Jansen Creek Member (Feldmann *et al.*, 1991).

Both the RB18 and RB38 localities are located in the upper Oligocene to lower Miocene Pysht Formation, which is estimated to be 1,100–1,400 m thick (Snaveley *et al.*, 1978). Age estimates for the Pysht Formation have been determined using foraminifera (Rau, 1964; Snaveley, 1983) and molluscs (Addicott, 1976). The Pysht Formation overlies the Makah Formation, and has been interpreted to have been initially deposited in a deep marginal basin, 300–1,830 m, that subsequently shallowed near the top of the formation (Rau, 1964; Addicott, 1976).

*Remarks.*—The fossil material may be referred to *Callianopsis* based on several criteria. The overall shape of the abdominal somites is similar in the fossil specimens to those of extant *Callianopsis*; unfortunately, the sixth somite is poorly preserved in the fossils, so that the sharp lateral spine on that somite could not be observed. The dorsal carapace of the fossil material exhibits a dorsal oval and cardiac prominence that are diagnostic of the genus *Callianopsis* (Manning and Felder, 1991). In addition, Karasawa (1993) reported fossil specimens of *Callianopsis* that possessed a dorsal oval; these specimens displayed major cheliped mor-

phology very similar to the fossil specimens recovered from Washington.

The major chelipeds possess several characteristics that permit referral of the fossil specimens to the genus *Callianopsis*. The merus of the major cheliped of *Callianopsis* possesses a small distal spine located on the lower margin (Figs. 1G, 2G); this spine was observed in male specimens of *Callianopsis clallamensis* (Fig. 5C). In addition, the merus possesses a longitudinal ridge extending from the distal margin approximately three-quarters of the distance along the length of the merus (Figs. 5C, 6A). The carpus of *Callianopsis* possesses a paddle-like flange on the lower margin, and this flange is seen in specimens of both sexes of *Callianopsis clallamensis*. The carpus of *Callianopsis* also possesses a blunt triangular extension on the upper proximal margin, where it articulates with the merus. This character is seen in the fossil specimens.

Several aspects of the chelae of the fossil specimens are comparable to characters ascribed to the genus *Callianopsis*. In addition, these characters exhibit obvious dimorphism that parallels the differences between males and females in the sole extant species of *Callianopsis*. In male specimens of *Callianopsis goniophthalma* (Figs. 1G, 4A) and fossil specimens originally attributed to *Callianassa clallamensis* (Fig. 5), the major chela is nearly square and wide, especially on the upper margin. Both species possess a triangular tooth on the distal margin in the notch between the two fingers and another positioned about one-half of the way along the fixed finger. Each possesses large setal tubercles on the outer surface of the manus and an inflated ridge paralleling the distal margin at the articulation of the movable finger with the manus. Each possesses a row of small setal pits paralleling the lower margin and a similar arrangement of setal tubercles on the fixed finger. The distal margin of each extends slightly obliquely from the upper to lower margin. The inner margin of the manus in both possesses an inflated ridge extending along the distal margin that possesses a scattering of small tubercles. The movable finger of each exhibits a ridge extending along the upper part of the outer surface; the ridges are initially composed of closely spaced tubercles. The movable finger of each is arcuate, and possesses a row of setal pits along

Table 12. Tabulation of handedness in both sexes of *Callianopsis clallamensis* (Rathbun). The sex of approximately 98 individuals could not be determined.

Sex	Right	Left	R/L ratio	Handedness undetermined
Male	30	28	1.07	0
Female	22	9	2.44	1

the outer surface and two rows of setal pits on the upper surface. Minor differences include a stronger ridge on the fixed finger in the Recent male specimens, and larger tubercles on the manus and movable finger in the fossil specimens.

In female specimens of *Callianopsis goniophthalma* (Figs. 2G, 4B) and fossil specimens originally referred to *Callianassa twinensis* (Figs. 6, 7), the manus is nearly equidimensional and is thin, especially along the lower margin. Both species possess a distal margin that first extends perpendicular to the upper margin and then extends at about a 45 degree angle until it meets the movable finger; the distal margin also has a sharp, triangular tooth positioned between the two fingers. The fossil specimens possess a shallow sulcus just proximal to the sharp tooth. Each exhibits a sharp ridge extending along the fixed finger that also possesses a row of setal tubercles positioned above and paralleling it. Each has a row of small setal tubercles paralleling the lower margin and an arrangement of tubercles on the manus. The movable finger of each possesses a ridge extending along the entire length of the finger, and in both the Recent and fossil species, the ridge initiates in several closely spaced tubercles. Both have a similar arrangement of setal pits on the movable finger, but the fossil specimens appear to lack the serrate ridge evident in the Recent specimens. Female specimens of *Callianopsis clallamensis* exhibit a definite tendency for the major chela to be on the right first pereiopod (Table 12). This tendency is not seen in Recent specimens; however, it should be noted that there are many more fossil specimens than Recent specimens, and that the fossils may represent a more accurate sample of handedness in the females of *Callianopsis*.

Because the fossil specimens possess a wide range of characters attributable to the Recent genus *Callianopsis*, they are referred to that genus with confidence. Analysis of

many genera in the families Callianassidae and Ctenochelidae shows that the combination of characters including a small, distal meral spine and a central meral keel, a carpus with a paddle-like flange, major chelae with a tooth on the distal margin and on the fixed finger (in the males only), and unequal major chelipeds is unique to the genus *Callianopsis*. The numerous similarities between the male specimens of *Callianopsis goniophthalma* and fossil specimens originally referable to *Callianassa clallamensis* and, in addition, similarities between the female specimens of *Callianopsis goniophthalma* and fossil specimens originally referable to *Callianassa twinensis* clearly suggest that the two fossil species should be referred to a single species and that they represent sexual dimorphs of that species, *Callianopsis clallamensis* (Withers).

This new material extends the record of the genus *Callianopsis* in North America at least into the Oligocene and perhaps into the late Eocene, with the discovery of female specimens of *Callianopsis clallamensis* in the late Eocene Jansen Creek Member of the Makah Formation. Interestingly, the Oligocene-early Miocene specimens reported in this study are quite similar to the Recent specimens of *Callianopsis* found on the Pacific Coast of North America.

Because of the clear evidence that sexual dimorphs of the genus *Callianopsis* exist, it is possible that Japanese species referred to that genus could also be one of a pair of sexual dimorphs. Reexamination of the Japanese material seems warranted based upon these new findings. It would be interesting to determine exactly how many fossil Japanese species of *Callianopsis* exist, since some could represent sexual dimorphs, and, in addition, to determine whether extant Japanese species of *Callianopsis* exist. In fact, the Japanese species *Callianopsis muratai* (Nagao, 1941), originally assigned to *Callianassa*, was reported to exhibit two varieties (Nagao and Huzioka, 1938). Nagao and Huzioka (1938) figured several specimens, and plate VI (I) no. 7 appears to represent a female, and plate VI (I) no. 10 appears to represent a male of *Callianopsis muratai* (Nagao). Subsequently, in 1941 Nagao erected a new species, *Callianassa elongatodigitata*, for material collected from the same unit as *Callianopsis muratai*. Both of these species

have been reassigned from *Callianassa* to *Callianopsis* (see Kato and Karasawa, 1994). Upon examination of these two species, it appears that Nagao may have assigned males to *C. muratai* and females to *C. elongatodigitata*. In 1941, Nagao named another species, *Callianassa kusiroensis* that he described as being intermediate in form between *Callianopsis muratai* and *Callianopsis elongatodigitata*. It seems probable that *Callianassa kusiroensis* Nagao, 1941, is also referable to the genus *Callianopsis* and may be synonymous with either *C. muratai* or *C. elongatodigitata*. However, reexamination of the type material is necessary to confirm revision of these three taxa. Analysis of other Japanese species of *Callianopsis* could help determine the range of variation in the genus and the diversity of the genus in terms of numbers of species over geologic time.

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